WASHINGTON
# SCIENCE TRENDS

HIGHLIGHTS

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## * THE "SERVO-SOLDIER" CONCEPT

The Army is interested in development of a "Servo-Soldier" concept which would provide an individual soldier with a means for increasing his strength, endurance, mobility and resistance to enemy-imposed combat environments. Ideas which may aid in this endeavor are being solicited. Here are some details:

✓ Mechanical Suit -- The concept visualizes a mechanical "exoskeletal" type suit with a self-contained power source, automatically controlled and guided by the natural responses and senses of the wearer. As the soldier moves his hands, arms, legs and feet the power mechanism would be automatically activitated -- multiplying his strength in much the same manner as vehicle power brakes and power steering mechanism respond to foot pedal and steering wheel movements.

✓ Structural Design -- The structural design of the apparatus must conform with and respond to human physiological and psychological requirements. The exoskeletal shell would have power-activated splint-type attachments about the arms, torsos and legs -- so pivoted that the wearer could climb, crawl, run and lift with ease.

✓ Applications -- For logistics, the unit would be expected to have a significant impact upon handling heavy military items such as airdropped cargo, missile components and unitized supply. For combat, the mechanism would be designed to convert a soldier into a fast moving and highly mobile "one-man tank". This would protect against the various hazards of a global environment; nuclear bombardment with its thermal and radiological effects; bacteriological and chemical warfare, and the like. At the same time, he would have increased offensive capability.

✓ What has to be done? The military believes that the key to solution of this problem lies in:

- ø Providing sufficient articulation and control for the required agility.
- ø Integrating the mechanism with the soldier.
- ø Developing a miniaturized, lightweight, quiet, safe and reliable self-contained power source capable of providing an output of approximately four horsepower for a period of ten hours.

Is the "Servo-Soldier" Feasible? The military believes so. They point out that servomechanisms are available for adaptation to this concept. Some have already been applied for remote-controlled mechanical arm, hand and finger automations for handling contaminants, including radioactive materials. Others have been adapted to repetitive programming of mass-production processes. Now, it is believed, the time has come to apply these techniques on a whole-body basis.

* PROJECT APOLLO

This "Three-Man" spacecraft project, now undergoing industrial "feasibility" studies, can be expected to become an important source of research and development testing and procurement activities in the next decade. There are now indications that the National Aeronautics and Space Administration will accelerate this program, beyond the limits imposed by the Eisenhower Administration.

Here is a brief summary of some details of Project Apollo, as outlined to Congress during the past week:

✓ Goals -- This project involves the development of a manned spacecraft designed to allow its occupants to perform useful functions in space. It will be capable of manned circumplanetary flight, as a logical intermediate step toward future goals of landing men on the moon and the planets.

Design of the spacecraft will be flexible so that it can be used as an orbiting laboratory in space -- a necessary intermediate step before permanent manned space stations can be established in earth orbit. Such a laboratory would also serve for scientific measurements, or for testing technological developments.

Equally important would be the Apollo role in circumlunar flight -- going around the moon without orbiting the lunar surface. Design for such a flight would involve the solution of many of the problems that would later be associated with a man landing on the moon, particularly in the areas of earth reentry and recovery. In addition, manned circumlunar flight is the "ultimate" manned mission compatible with the current Saturn space booster program. Before circumlunar flights are attempted with Apollo, earth orbital flights will be required for spacecraft evaluation, crew training, and for the development of operational techniques.

Modular Construction -- In order to achieve the dual mission (orbiting laboratory and circumlunar flight) capabilities, NASA believes it may be desirable to employ the modular concept. Basically, a modular spacecraft would consist of three units -- a command center module, a propulsion module and a mission module. The command center will house a three-man crew during launch entry and reentry phases and will also serve as a flight control center during the remainder of the mission.

ø Propulsion Module will serve the main function of providing adequate propulsion for emergency escape considerations at any speeds up to maximum velocity. This module can also have the capability of making midcourse and terminal guidance corrections, and to place the spacecraft into an orbit around the moon, and eject it from a lunar orbit for return toward earth.

ø Mission Modules would differ for the circumlunar and earth orbital missions. For circumlunar flight, they would provide better living accomodations for the three man crew during flight, and also some equipment for scientific observations. For earth orbital flights, the mission module could be considerably heavier. As an earth orbital laboratory, ample capacity for scientific instrumentation and a reasonably long-lived orbit, would be possible.

ø Command Center Module would have to be designed to permit reentry at 25,000 miles per hour, or nearly one and a half times as fast as a reentering satellite. Protection from reentry heating would, therefore, be an exceedingly difficult task. Some suggested configurations would have control surfaces to permit a degree of maneuverability after the craft has returned to the atmosphere, to control the flight path, and to allow a landing at a preselected site. Certain configurations would permit conventional airplane-type landings on a landing field. All of the designs should be capable of surviving both ground and water landings.

( Continued )

Here are some of the requirements in the Apollo system:

✓ An environmental control system which can supply a livable atmosphere for the crew, for perhaps several weeks. Attitude control systems, to control the spacecraft attitude and direct it in the proper direction. Suitable power supplies.

✓ An on-board propulsion system. This would be required to get the spacecraft back toward the earth from any point between the earth and the moon in case of launch vehicle malfunction or a different kind of emergency. NASA calculations indicate that about one-third the total weight of the spacecraft would be tied up in on-board propulsion.

✓ Communications Systems are another requirement. Suitable pilot displays would be needed to permit the pilot to control the craft, to reenter the appropriate corridor toward earth, and to land at the preselected site.

Status -- Development program includes feasibility studies now underway by industrial contractors. This will be followed by preparation of specifications, and the design, development and manufacturing phases of the spacecraft. While this is going forward, a development test program using Little Joe, Atlas, Atlas-Agena and Saturn launch vehicles will be carried on. Results from the Mercury flight test programs will be incorporated into the design as they become available. Upon completion of this design and development effort, manufacture of the Apollo spacecraft and its systems will be started. NASA believes that this program, as currently planned, should lead to the first manned flight of the Apollo spacecraft system during the middle of this decade. Circumlunar flights would follow as soon as systems development and qualification programs have confirmed satisfactory operation.

* NASA LAUNCH VEHICLES

Here is a summary of the status of selected NASA launch vehicle programs:

✓ Scout -- Present payload assignments include micrometeorite satellites, ionosphere probe experiments and a United Kingdom-U.S. satellite. During 1962 five additional Scouts will be launched. In conjunction with the Defense Department, an improvement program to increase payload capability by some 40 percent is planned.

✓ Thor-Agena B -- Three to be launched in Fiscal 1962. Missions include communication and meteorological satellites as well as solar and geophysical observatory satellites.

✓ Atlas-Agena B -- In addition to Air Force use, NASA will employ this vehicle to place a 750 pound payload on the moon. Other missions include a geophysical observatory and communication satellites. Five launches in Fiscal 1962.

✓ Centaur -- NASA missions include soft lunar landings, lunar orbiters and planetary exploration. Expectations are that 2500 pounds can be sent to the moon, and some 1500 pounds to Mars and Venus employing Atlas first stage and liquid hydrogen/liquid oxygen upper stage.

✓ Saturn -- Initial or C-1 version will have two upper stages with Centaur-type system. First version will be used in developing the capability for reentry into Earth's atmosphere (See Project Apollo); in training crews for outer space missions in relatively low earth orbits and possibly larger orbiting astronomical observatories, and military missions. First of ten developmental vehicles will be launched this Summer, and last in 1964. A C-2 version would give some 2½ times the payload capabilities and make possible manned circumnavigation of the moon and unmanned orbiting of the nearer planets. Work on this will begin in "limited" fashion in Fiscal 1962.

✓ Nova -- NASA plans to study this concept to help define exact configuration and will compare relative merits of an all-chemical vehicle as opposed to the use of nuclear rockets in upper stages, or whether Nova could be replaced by orbital refueling techniques using the C-2 Saturn.

* RESEARCH AND DEVELOPMENT GOALS

Here is a summary of goals for the next five years as recently set forth by Rear Admiral R. K. James, Chief of the Bureau of Ships. Close to $200 million is spent annually for BUSHIPS r&d with private industry, non-profit institutions and colleges.

This listing may be of value to organizations planning r&d proposals:

✓ Automation of shipboard equipment -- to reduce the number of personnel needed for operation and maintenance of ships. This is a high priority project which should be completed in time for the 1963 shipbuilding program.

✓ Development of a 500-ton hydrofoil craft by 1965 -- utilizing supercavitating foils and capable of speeds up to 90 knots.

✓ Development of cushion hydroskimmers (Navy term for Ground Effect Machines) and by 1963 the determination of the practicality of a 2,000-ton seagoing air cushion vehicle.

✓ By 1963, development of a HY-150 steel (yield stress 150,000 p.s.i.) for use in deep-diving submarines. Concurrently, the development of effective fabrication and welding techniques.

✓ Increase lifetime for propulsion plants -- to between 20 and 30 years of reliable operation.

✓ Simplify and ruggedize all equipment for shipboard installation.

✓ Energetically support miniaturization of electronic systems for ships.

✓ Diminish the noise produced by ships.

✓ Design new ships so as to require a minimum of ship conversion to accommodate new weapons systems.

✓ Coordinate the design of all electronic equipment including fire control, surface search and air search radars, sonars, communications, electronic counter measures and counter counter-measures systems into an overall complex to minimize duplication of components and to maximize flexibility.

✓ Continue work on nuclear propulsion, particularly for powering smaller types of ships.

Long-range studies -- a wide variety of advanced concepts are under study for programs 10 to 15 years in the future. One area is energy conversion, including the use of waste fission products. Another is the development of a chemical fuel source which does not produce gas during its reaction, and which can be stored indefinitely before use. The Navy is also interested in the possibility of extracting energy directly from sea water utilizing the motion of the waves and other oceanic phenomena.

For the latest information on the research and development organization of the Navy's Bureau of Ships see the following page.

## RESEARCH AND DEVELOPMENT ORGANIZATION OF THE BUREAU OF SHIPS

| Personnel | Telephone | General Cognizance |
|---|---|---|
| CAPT Edward J. Fahy, USN<br>Assistant Chief of Bureau<br>for Research and Development<br>Room 3020, Main Navy Building | OX-6-1549 | Entire Research, Development, Test and Evaluation Program of the Bureau of Ships, except for nuclear propulsion of ships. |
| Dr. G. C. Sponsler<br>Chief Scientist,<br>Research and Development<br>Room 3018, Main Navy Building | OX-6-5864 | Broad assessment of research and development program as to general direction in light of current status of technology and future over-all direction of program. |
| CDR C. G. Spoerer, Jr. USN<br>Director, Applied<br>Research Division<br>Room 3203, Main Navy Building | OX-6-2156 | Research, Development, Test, and Evaluation Program in area of ships, including hull structures, propulsion, ship control, logistics, habitability, and ship miscellaneous; ship noise measurement and reduction; and applied sciences, materials and fuels, oceanography, cold weather, direct energy conversion, and statistical engineering. |
| LCDR F. W. Anders, USN<br>Director, Advanced<br>Concepts Division<br>(Acting)<br>Room 3018, Main Navy Building | OX-6-6547 | Generation and exploitation of new ideas made possible by the most recent developments in science and engineering that can be applied to the design of ships, ship systems, and operation thereof, with particular emphasis on surveillance techniques, defense and deception methods, and energy generation and transfer. |
| CAPT P. C. Combs, USN<br>Director, Warfare Systems<br>Division<br>Room 2510, Main Navy Building | OX-6-4811 | Research, Development, Test, and Evaluation Program in areas of command support, including communications, command control, data processing, astronautics, navigation, and electronics support; and detection and countermeasures, including air and surface detection of targets, mine and torpedo countermeasures, ABC defense, personnel protection, intercept, deception and jamming, visibility and concealment, and harbor defense. |
| CAPT W. F. Cassidy, USN<br>Director, Antisubmarine<br>Warfare and Ocean Surveillance Division<br>Room 3006, Main Navy Building | OX-6-3096 | Research, Development, Test, and Evaluation Program in areas of antisubmarine warfare and ocean surveillance, including mobile, deployable, and fixed systems, non-acoustic techniques and classification, and range instrumentation and sound ranges. |

(Above individuals to be addressed at Bureau of Ships, Department of the Navy, Washington 25, D.C.)

## RESEARCH CHECKLIST

□ SCINTILLATION SPECTROMETER: The Navy has developed a new device to measure background radiation in the ocean at depths of up to 6,000 feet in a program which may lead to the use of the sea as a laboratory for conducting nuclear research problems which require low backgrounds from cosmic rays and surrounding media. The device consists of pressure switches to indicate depth; a battery pack; transistor pre-amplifier; photomultiplier tube to convert light from detector to electric signals and a sodium iodide (thallium activated) crystal. A shipboard 128-channel analyzer records digitally the energy spectrum within a pre-selected range for pulse-height sorting.

(R&D by G. K. Riel, J. P. Dolfis and D. G. Simons, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.)

□ CRYOGENIC TANK INSULATION: The National Aeronautics and Space Administration has found that ice and frost can be used as an insulating medium to prevent "boil off" losses in cryogenic propellant tanks. The ice and frost forms on the tank walls when the tank is filled properly. Although the frost insulates only about one-fourth as well as the cork sheet-board used in most insulated tank tests, the results are said to appear "promising." A potential advantage of frost over cork insulation is that it ablates during the climb through the atmosphere, and lightens the vehicle during the final part of the flight.

□ CALCULATING RADIATION FIELDS: The National Bureau of Standards has developed a so-called series-expansion method for calculating the radiation received by a detector from a rectangular source. The technique, developed primarily for use in problems of shielding against gamma radiation, also has potential applications in other problems involving rectangular sources of radiation, such as occur in photometry and food irradiation. A similar investigation is now in progress involving a circular disk source. For example, calculations could be made of the neutron flux around the face of a cylindrical thermal column of a research reactor.

(For details, write National Bureau of Standards, Office of Technical Information, Washington 25, D. C. regarding "Radiation Field from a Rectangular Source.")

□ PORTABLE SPECTROPHOTOMETER: The Army is testing a portable reflectance spectrophotometer to measure surface reflectance of soils and vegetation in natural environments. Data obtained from the instrument are used as a guide in development of specific aerial photographic techniques for the detection of obstacles, by permitting accurate selection of film-filter characteristics. The portable device employs a high pressure Xenon lamp, to measure diffuse reflectance over a spectral range of 250-1500 millimicrons. The sample area viewed is about six inches in diameter and can be examined in an undisturbed state -- an important consideration since disturbed samples may show marked differences in reflectance properties.

(R&D by Perkin-Elmer Corp., Norwalk, Conn. and U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va. "Major credit" also given to H. Keegan, National Bureau of Standards, and R. N. Colwell, University of California, Berkeley, Calif.)

- TWIST-TURN WAVEGUIDE JUNCTION: The Navy has modified a so-called "twist-turn" waveguide junction for use in precision tracking radar systems. The unit can replace two waveguide components often found in combination such as a 90-degree waveguide twist and a 90-degree bend. Modifications were required because commercially available units fell short of meeting anticipated bandwidth requirements.

  (R&D by R. S. Potter, Radar Division, Tracking Branch, U. S. Naval Research Laboratory, Washington 25, D. C.)

- MISSILE MOISTURE DETECTOR: Army Engineers have announced development of an electrolytic hygrometer said to be capable of detecting moisture in high pressure air up to 6000 psi, and also of measuring moisture content down to a free air dew point of -100°F. The instrument consists basically of an electrolytic cell, an ammeter and a direct current power source, with associated pneumatic and electrical controls. The analyzer absorbs and simultaneously electrolyzes all moisture from a sample gas stream. This is accomplished in a small diameter tube containing a pair of closely spaced platinum wires wound as a double helix on its inner surface, and coated with a thin film of phosphorous pentoxide, a material with a strong affinity for moisture.

  (Equipment built by Consolidated Electrodynamics Corp. and Beckman Instruments, Inc. under contracts with the U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va.)

- SILICONE LUBRICANTS: The Navy has made public details of a new oxidation inhibitor for silicone liquids which increases by one hundred fold the useful life of silicone lubricants in the 500-600°F temperature range. In certain applications this can be increased by a factor of five.

  (Details are contained in Technical Report NRL-54-74, U. S. Naval Research Laboratory, Washington 25, D. C.)

- ADHESIVE BONDING OF UNUSUAL METALS: Missile and nuclear weapon design and other advanced ordnance configurations frequently require the bonding of unusual metals and tests of such bonding have been reported by the Feltman Research Laboratories of the Picatinny Arsenal. The materials tested were uranium 238, silver, gold, chromium, beryllium, titanium and stainless steel. Several adhesives were used but the two primary bonding agents investigated were a polyester and a polysulfide-modified epoxy.

  ("Adhesive Bonding of Metals for Advanced Ordnance Applications", Department of the Army Project 593-32-002 is available through military channels or at 75 cents from OTS, U. S. Department of Commerce, Washington 25, D.C.)

- ULTRASONIC MEASURING: Broad study of ultrasonic techniques for measuring bond strength and locating defects in ceramic coatings on a metal base has been undertaken by the Armour Research Foundation for the Wright Air Development Division of the USAF. Three general methods were investigated: high frequency techniques (1-10mc/s), low frequency techniques (14 kc/s) and simultaneous use of high and low frequencies. A number of specific techniques were studied in each of these categories. Some of the techniques tested are adaptable to non-destructive testing of flame-sprayed or vapor-deposited ceramic coatings on high temperature metals such as tungsten and steel. Other of the techniques provide a means of observing the changes of stress patterns with time as specimens of several types are tested to destruction. Consideration was also given to the design of image systems to display the ultrasonic data.

  ("Ultrasonics and Ceramic Coatings", is available through military channels or for $1.50 from OTS, U. S. Department of Commerce, Washington 25, D. C.)

# PUBLICATION CHECKLIST

- ☐ REFRACTORY METALS IN EUROPE, a brief survey on applications, research and production activities in Europe and the USSR, with the emphasis on advanced materials. 5 Pages. Free to Government agencies, contractors, subcontractors and their suppliers. (Write Defense Metals Information Center, Columbus 1, Ohio regarding DMIC Memorandum No. 83)

- ☐ HELIUM PRODUCTION, a Government report providing detailed information on a helium extraction plant at Keyes, Oklahoma. Includes pertinent technical materials and facts regarding operating costs. Single Copies Free. (Write Publications-Distribution Section, U. S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh 13, Pa. for Information Circular 8018)

- ☐ INTEGRATED DATA PROCESSING AND COMPUTERS, a report by a mission of European experts on trends in the United States. Covers basic concepts, the service center and educational aspects. 68 Pages. $1.75. (Write OEEC Mission Publications Office, 1346 Connecticut Avenue, N. W., Washington 6, D. C.)

- ☐ SOLID STATE DETECTION SYSTEMS, a report and literature survey of solid state gamma and/or neutron detection systems for dosimetric purposes. Covers such topics as coloration, luminescence, electrical effects, chemical effects and optical rotation. 64 Pages. (U. S. Army Chemical Research and Development Laboratories Report No. 3020 available through military channels or at $1.75 from OTS, U. S. Department of Commerce, Washington 25, D. C.)

- ☐ RESEARCH PROBLEMS IN MATHEMATICS EDUCATION, a review of completed research and a summary of problem areas and proposals for further studies. 130 Pages. 55 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D. C. for Publication No. OE-12008)

- ☐ NUCLEAR SCIENCE AND ENGINEERING EDUCATION, an excellent compilation of education programs and facilities in these fields, including information on institutions offering degrees and those which have special research facilities. 76 Pages. (Write University Relations Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.)

- ☐ HIGH STRENGTH AIRCRAFT STEELS, an Air Force report on the status of research and development in this area. Includes chemical descriptions, processing techniques, arc-welding and the development of heat treatable filler wires, as of 1959. (WADC Technical Note 59-326 now available through military channels or at $1 from OTS, U. S. Department of Commerce, Washington 25, D. C.)

- ☐ GEOPHYSICAL RESEARCH - ROCKETS AND SATELLITES, USSR, a translation for the U. S. Government of an article by two Soviet authorities on the results of recent space ventures and an outline of some problems yet to be solved. 17 Pages. Single Copies Free. (Write NASA, ATTN: CODE BID, 1520 H Street, N. W., for NASA Technical Translation F-57)

- ☐ COSTS OF NUCLEAR POWER, a new revision of the Atomic Energy Commission's survey which includes information on several new reactor projects. Breaks down, into major components, the capital costs of a number of U. S. and foreign nuclear power plants and includes much supplementary information. 40 Pages. (Available through AEC channels or at 50 cents from OTS, U. S. Department of Commerce, Washington 25, D. C.)